

OBSERVATIONS ON BUCKLEYA (THESIACEAE) IN CHINA

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ABSTRACT

Buckleya lanceolata (Siebold & Zucc.) Miquel (Thesiaceae) from Japan and *B. henryi* Diels from China have been recognized as distinct species since *B. henryi* was described in 1908. Characters to separate them have neither been questioned nor analyzed in detail. Separation of the two species has most likely been based on geography as much as, if not more than, morphological features. During a class field trip with students from Zhejiang University, Hangzhou, and North Carolina State University, Raleigh, North Carolina, in 2008 we visited a number of sites in southern Anhui and Zhejiang provinces, China. Among the collections made on Qiyun Shan, Xiuning Xian, Anhui, was a most interesting shrub of the genus *Buckleya* (Thesiaceae), which we later determined to be *B. angulosa* S.B. Zhou & X.H. Guo. Based on our observations of specimens of *Buckleya* in the Harvard University Herbaria, we discovered that *B. angulosa* shares characteristics of both the Chinese *B. henryi* and the Japanese *B. lanceolata*. Similarities and differences among these taxa are discussed and the possibility of paleo hybridization is raised.

CHINESE ABSTRACT

摘要: 自1908年*Buckleya henryi* Diels发表以来, 中国分布的*B. henryi*与日本分布的*B. lanceolata* (Siebold & Zucc.) Miquel一直被认为是2个不同的种, 但二者分类特征的可靠性尚未有人怀疑或深入分析。这两个种的成立很可能是由于地理分布和形态的差异。今年我们在安徽休宁县齐云山的植物学野外实习中, 发现了米面蕨属一种非常有意思的植物, 即最近发表的棱果米面蕨 (*B. angulosa* S.B. Zhou & X.H. Guo)。通过对哈佛大学标本馆(A)米面蕨属标本的观察, 我们发现毛被和叶形并非*B. henryi*和*B. lanceolata*的可靠分类依据; 棱果米面蕨分别具有中国分布的*B. henryi*与日本分布的*B. lanceolata*的特征。本文对这些种形态特征的异同进行了讨论, 推测棱果米面蕨可能是*B. henryi*和*B. lanceolata*的杂交后代。关键词: 米面蕨属; 檀香科; 分类; 系统发育; 远古杂交

Key Words: *Buckleya*, Thesiaceae (Santalaceae), China, taxonomy, phylogeny, paleo hybridization

During a class field trip in 2008 with students from Zhejiang University, Hangzhou, China, and North Carolina State University, Raleigh, North Carolina, U.S.A., we visited a number of sites in southern Anhui and in Zhejiang provinces. One of the most floristically interesting areas was Qiyun Shan, in Xiuning Xian, Anhui Province. Among the rich assemblage of plants on Qiyun Shan, was a most interesting shrub of the genus *Buckleya* Torr. (Thesiaceae). Although *Buckleya* has been placed traditionally in the Santalaceae, it will be placed in Thesiaceae by D. Nickrent (manuscript submitted) in the forthcoming treatment of the genus in the *Flora of North America*; also Nickrent et al. in press).

Upon returning to the United States, the collection of *Buckleya* from Qiyun Shan was compared with specimens of *B. lanceolata* (Siebold & Zucc.) Miquel (Fig. 1) from Japan and with specimens of *B. henryi* Diels from China, since it did not fit descriptions in the monograph by Carvell and Eshbaugh (1982) or any of the species of *Buckleya* in the *Flora of China* (Xia & Gilbert 2003). The plants from Qiyun Shan resembled the Japanese *B. lanceolata* in the longitudinal grooves of the mature fruit and in the broader and somewhat caudate-acuminate leaves, but they resembled *B. henryi* in having terminal and axillary inflorescences. *Buckleya lanceolata* from Japan has only terminal inflorescences, but *B. henryi* from China sometimes produces both axillary and terminal inflorescences (Carvell & Eshbaugh 1982). The trichomes of *B. lanceolata* are reported



EX TUS

Herbarium Tohoku University
Buckleya lanceolata (Sieb. & Zucc.) Miquel
ツツバネ

In deciduous forests (mainly *Fagus japonica*, *Quercus serrata*, *Acer* spp.), on roadside.

Japan. Fukushima-ken: Futaba-gun, Namie-machi, from Kitazawa to below Mt. Tekura-yama, along the River Takasegawa, alt. 120-400 m. 浪江町 南瀬川溪谷沿山
August 1, 1983
N. Ohashi & Y. Ueno 8557 北沢一平家山下

HERBARIUM
OF THE
ARNOLD ARBORETUM
HARVARD UNIVERSITY

FIG. 1. *Buckleya lanceolata* (Siebold & Zucc.) Miquel. Specimen collected in Japan, Fukushima Prefecture, Futaba-gun, Namie-machi, along the Takase River, H. Ohashi & Y. Ueno 8557 (A). Note similarity of leaves and flowers in Figs. 1 and 2.

to be both uniseriate and multicellular while *B. henryi* has minute conical and/or papillate trichomes ("hairs") on the vegetative parts (Carvell and Eshbaugh, 1982). Some specimens of *B. lanceolata* from Japan, however, do not have the long trichomes, for example, *H. Ohashi* & *Y. Ueno* 8557 (A) from along the Takase River in Namie-machi, Futaba-gun in Fukushima Prefecture. In fact, the *Ohashi* & *Ueno* specimen, collected north of Tokyo, closely resembles our Anhui collections vegetatively. In many ways the plants of *Buckleya* from Anhui appear to be hybrids between the Japanese *B. lanceolata* and the Chinese *B. henryi*. After making these observations we became aware that plants from Tianzhu Shan, Anhui, and matching the characteristics of our find on Qiyun Shan, were described and named *B. angulosa* by S.B. Zhou & X.H. Guo (2004).

Housed in the Harvard University Herbaria (A, GH) are other specimens from southern Anhui that resemble the plants we saw in the field. Specimens of *Buckleya* from farther north in Henan and from the Qinling (and Funyu) Mountains, however, have more slender, elliptic leaves and the fruiting sepals are smaller, but at a quick glance and without careful measurements, both characters appear to be variable. The plants from Anhui have leaves that are broader toward the base, or at least below the middle, and the apex is acuminate-caudate, but not as obviously acuminate-caudate as in *B. lanceolata* from Japan. Most plants of *B. lanceolata* have uniseriate, multicellular trichomes on the vegetative parts, particularly near the base on the lower surface of the leaves, plus minute conical projections (trichomes). *Buckleya henryi* lacks multicellular trichomes, but has the minute conical projections. Although the plants from Anhui resemble the Chinese *B. henryi* in pubescence, several specimens of *B. lanceolata* from Japan also have similarly shaped leaves and similar pubescence. Pubescence and leaf shape are therefore not 100 percent reliable features for distinguishing the species of *Buckleya* in Asia.

The illustration of *Buckleya angulosa* provided by Zhou and Guo (2004) matches our collections (Fig. 2) well in showing the axillary inflorescences and elliptic sepals on the fruit. Although they provide a diagnostic key to separate the Chinese species of *Buckleya*, *B. henryi* is neither mentioned in their key to the species in China nor in the narrative of their paper. The narrowly elliptic leaves in their illustration of *B. angulosa*, however, resemble more closely those of *B. henryi* than they do those of our collection from Qiyun Shan. Our specimens also lack the peculiar apical projection on the leaves, shown in the illustration of Zhou and Guo, and which appear sporadically on all Asian species of *Buckleya*.

Buckleya henryi may not have been considered to be a distinct species by Zhou and Guo (2004), since it was placed in synonymy under *B. lanceolata* by Tam (1988) in the treatment of the genus in *Flora Reipublicae Popularis Sinicae* volume 24. Xia and Gilbert (2003), however, who also recognize two species of *Buckleya* in China, *B. graebneriana* Diels and *B. henryi*, noted in their treatment in the *Flora of China* that *B. henryi* has been confused with the Japanese *B. lanceolata*.

In examining specimens of *Buckleya* from Japan and China, one cannot fail to speculate on how the species might have been treated had they all occurred in China, or all in Japan. Would separate species have been recognized, or even distinct taxa at an infraspecific rank? The characteristics used to separate them are not always clear and considerable plasticity can be seen in leaf shape, pubescence and length of the sepals on the fruit. Although the differences in most individuals of *B. henryi* and *B. lanceolata* can easily distinguish them, careful study is needed to determine if clear, discontinuous distinctions occur in the individuals that seemingly combine characteristics of the two species. Might these seemingly intermediate plants be examples of paleo hybridization where the offspring of crosses between species ($B. henryi \times B. lanceolata = B. angulosa$?) brought together sympatrically during the Pleistocene have maintained themselves on the mainland after the extinction of one of the parents there?

Carvell and Eshbaugh (1982) speculated that plants with both axillary and terminal inflorescences were ancestral in *Buckleya*, with terminal inflorescences being derived. Of the four species recognized by them, they considered *B. henryi* to be most similar to the ancestral form, with *B. lanceolata* being a direct descendent. The molecular analysis by Li et al. (2001) supports the relationships hypothesized by Carvell and Eshbaugh. Now, with the recognition of *B. angulosa* and the complexities it adds to the understanding of this small, but biogeographically interesting and important genus, a comprehensive review of the taxonomy



Plants of China

Santalaceae
Buckleya angulosa S. B. Zhou & X. H. Guo

Anhui Province, Xiuning Xian: Qiyun Shan, 29°48'38"N, 118°13'37"E, 480 m. Mixed broadleaved forest of deciduous and evergreen trees, including *Machilus*, *Quercus*, *Liquidambar formosana*, *Chimonanthus indicifolius*, *Sargentodoxa*, *Lindera* and other Lauraceae. Dry, steep slope. Intermixed with other shrubs. Arching shrub; stems ca. 2.5 m long; bracts (wings) on every mostly 4, but sometimes 3 or 5; sepals green; petals green; stamens green. Flowers axillary and terminal as in Chinese *B. henryi*, but striations on fruit and broadly ovate, acuminate and somewhat caudate leaves resemble *B. lanceolata*. Pubescence of vegetative parts matches *B. henryi* and some specimens of *B. lanceolata* from Japan. See Carvell, W. N. and W. H. Eshbaugh 1982. A systematic study of the genus *Buckleya* Santalaceae: Castanea. 47: 17-37. See also Zhou, S. B. and X. H. Guo. 2004. A new species of *Buckleya* (Santalaceae) from Anhui. *Gulesia* 24: 332-333.

D. E. Boufford, C. X. Fu, Q. Y. Xiang & Y. P. Zhao
40515 3 June 2008

Harvard University Herbaria

FIG. 2. *Buckleya angulosa* S.B. Zhou, & X.H. Guo. Specimen collected in China, Anhui, Xiuning Xian, Qiyun Shan, D.E. Boufford, C.X. Fu, Q.Y. Xiang & Y.P. Zhao 40515 (A).

TABLE 1. Distinguishing features of the five species of *Buckleya*.

	<i>B. angulosa</i>	<i>B. distichophylla</i>	<i>B. graebneriana</i>	<i>B. henryi</i>	<i>B. lanceolata</i>
Leaf shape	Ovate to ovate-lanceolate	Narrowly lanceolate to lanceolate or elliptic	Ovate to widely elliptic	Narrowly lanceolate to lanceolate or elliptic, infrequently ovate-lanceolate	Widely elliptic to lanceolate to ovate-acuminate or ovate
Leaf apex	Abruptly acuminate to caudate	Narrowly acuminate	Narrowly acuminate or tapering smoothly to apex	Narrowly acuminate or tapering smoothly to apex	Abruptly acuminate-caudate
Leaf base	Cuneate to slightly rounded	Attenuate to slightly rounded	Cuneate to rounded	Attenuate to slightly rounded, rarely narrowly cuneate	Attenuate to slightly rounded
Sepals persistence	Persistent	Deciduous	Persistent	Persistent	Persistent
Sepals: fruit length	1.5–2 x longer than fruit	Sepals absent	1–1.5 x longer than fruit	1–2 x longer than fruit	2–4 x longer than fruit
Inflorescence position (both sexes)	Axillary and terminal	Terminal	Terminal	Axillary and terminal	Terminal
Trichomes	Needle-like, conical and papilla-like	Conical and papilla-like	Needle-like	Conical and papilla-like	Needle-like
Ovary/fruit surface	With longitudinal ribs and narrow grooves	Smooth	Smooth	Smooth-slightly sulcate	With longitudinal ribs and narrow grooves to smooth
Distribution	Eastern China	SE United States	East-central China	East-central China	Japan

and relationships within *Buckleya*, using both traditional field and herbarium studies in combination with modern methods, should be undertaken to resolve the complexity in the genus. *Buckleya distichophylla* (Nutt.) Torr., a rare endemic species of the southern Appalachian Mountains in the southeastern United States (Harper 1947; Musselman 1982; Piehl 1965), should be included in the analysis also, even though it was included in the recent phylogenetic analysis by Li et al. (2001).

To rectify the omission of *B. henryi* in *Flora Reipublicae Popularis Sinicae* and *B. angulosa* in the *Flora of China* treatments, we here provide a key to the three species in China. A comparison of all five species of *Buckleya* to show their distinguishing features is presented in Table 1.

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|--|-------------------------------------|
| 1. Ovary smooth, without ribs and narrow grooves; leaves ovate to widely elliptic, tapering smoothly to the acute to obtuse apex; inflorescences terminal; trichomes needle-like _____ | <i>Buckleya graebneriana</i> |
| 1. Ovary with longitudinal ribs and narrow grooves; leaves lanceolate to widely ovate or occasionally elliptic, apex acuminate to caudate; inflorescences terminal and axillary; trichomes needle-like, papilla-like and/or conical. | |
| 2. Leaves narrowly lanceolate to lanceolate or elliptic, infrequently ovate-lanceolate; trichomes papilla-like and/or conical _____ | <i>Buckleya henryi</i> |
| 2. Leaves ovate to ovate-lanceolate, abruptly acuminate to caudate; trichomes needle-like, conical and papilla-like _____ | <i>Buckleya angulosa</i> |

Label details for our collection of *Buckleya angulosa* are: **CHINA:** Anhui, Xiuning Xian, Qiyun Shan., mixed broadleaved forest of deciduous and evergreen trees, including *Quercus acutissima* Carruthers and *Q. fabri* Hance, *Liquidambar formosana* Hance, *Chimonanthus salicifolius* S.Y. Hu, *Sargentodoxa cuneata* (Oliver) Rehder & E.H. Wilson, *Machilus leptophylla* Hand.-Mazz. & Chun, *Lindera glauca* (Siebold & Zucc.) Blume, *Sassafras tzumu* (Hemsley) Hemsley, *Phoebe sheareri* (Hemsley) Gamble, *Cinnamomum japonicum* Siebold and *Alangium kurzii* Craib (Alangiaceae), 29°48'38"N, 118°1'33"E; 480 m, 3 Jun 2008, D.E. Boufford, C.X. Fu, Q.Y. Xiang & Y.P. Zhao 40515 (A, NCSC, TI), and Y.P. Zhao Z080638 (HZU).

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REFERENCES

- CARVELL, W.N. AND ESHBAUGH, W.H. 1982. A systematic study of the genus *Buckleya* (Santalaceae). *Castanea* 47:17–37.
- HARPER, R.M. 1947. Preliminary list of Southern Appalachian endemics. *Castanea* 12:107.
- LI, J.H., D.E. BOUFFORD, AND M.J. DONOGHUE. 2001. Phylogenetics of *Buckleya* (Santalaceae) based on its sequences of nuclear ribosomal DNA. *Rhodora* 103:137–150.
- MUSSELMAN, L.J. 1982. The Santalaceae of Virginia. *Castanea* 47:276–283.
- NICKRENT, D.L. In press. Thesiaceae. In *Flora of North American Editorial Committee. Flora of North America* 12:x–x
- NICKRENT, D.L., V. MALÉCOT, R. VIDAL-RUSSELL, AND J.P. DER. In press. A revised classification of Santalales. *Taxon*.
- PIEHL, M.A. 1965. Abstract: Observations on the parasitic behavior of *Buckleya distichophylla* (Santalaceae). *Amer. J. Bot.* 52:626.
- TAM, P.C. 1988. *Buckleya* (Santalaceae). In H.S. Kiu and Y.R. Ling, eds. *Flora Reipublicae Popularis Sinicae* 24: 54–57.
- XIA, N.H. AND M.G. GILBERT. 2003. *Buckleya* (Santalaceae). In Z.Y. Wu and P.H. Raven, eds. *Flora of China* 5:208–209.
- ZHOU, S.B. AND X.H. GUO. 2004. A new species of *Buckleya* (Santalaceae) from Anhui. *Guihaia* 24:332–333